

Maturing the TRL of a Complete CDEX Dating Instrument

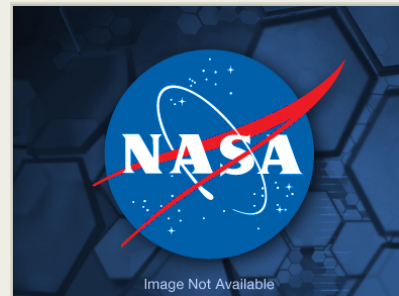
Completed Technology Project (2017 - 2020)



Project Introduction

Science goals We have developed an instrument to assess and revise the history of the inner solar system, search for organics, and reveal the history of habitability called "the Chemistry and Dating EXperiment" (CDEX) instrument. The CDEX instrument is uniquely able to map microscopic chemical and organic context of a sample, while simultaneously determining age. The instrument measures rubidium-strontium (Rb-Sr) isotopes using laser ablation resonance ionization mass spectrometry (LA-RI-MS) for isobar free elemental separation. The RI lasers can be turned off to assess chemistry in LA-MS mode, or organics in two-step laser MS mode. This instrument was the basis for Discovery and Mars 2020 proposals, and planning is underway for future Discovery and New Frontiers opportunities. This proposal specifically addresses instrument TRL deficiencies identified under these earlier flight proposals, and will improve the TRL of the integrated instrument from 4 to 5-6.

Methodology This proposal focuses on 1) development of a Rb fiber laser, 2) development of a sample gripper and grinder subsystems, and 3) integration and validation of a complete TRL 5-6 CDEX instrument. Specifically, based on our successful development of Sr and ablation lasers under a 2014 NASA MatISSE, we will produce a Rb RI fiber laser subsystem, raising the laser subsystem TRL from 4 to 5-6. The fiber laser design, built in partnership with Aerospace Corporation, improves on the solid-state laser system we built earlier by reducing input power by 50%, increasing output power by 4X, reducing mass by 3X, and reducing optical interfaces by 10X. Reducing the number of optical interfaces is crucial to reducing alignment and contamination requirements. The Rb laser will then be tested and integrated with the existing Sr and ablation lasers subsystems, along with a contributed TRL 6-9 flight spare mass spectrometer from the University of Bern. The integrated CDEX will be lifetime tested in relevant environments at SwRI, and validated by repeating existing benchtop measurements. Sample handling for the instrument will be demonstrated, including development and testing of a sample gripper and grinder, followed by verification measurement on CDEX. The gripper and grinder development adapts existing high TRL technologies from MDA and HoneyBee Robotics to the CDEX instrument. Finally, we will continue our ongoing sample benchtop measurement campaign, expanding the suite of successful demonstration measurements, thereby raising the maturity of the LARIMS dating method. Proposal objectives 1) Define flight requirements, environments, and interfaces; 2) Develop, build, environmentally test, and validate a Rb fiber-laser subsystem; 3) Integrate all three lasers (Rb, Sr, and ablation) with a miniature mass spectrometer; 4) Verify and validate instrument performance; 5) Perform lifetime and lunar environmental testing; 6) Validate sample handling, including a gripper, grinder, and docking interface; 7) Build scientific support through ongoing bench-top dating measurements. Relevance These measurements are relevant for missions to the Moon, and Mars, as well as other inner solar system targets like Vesta. Specifically, the instrument is relevant to multiple NASA goals, such as: A) For Mars, the NRC Decadal Survey specifically supports:



Maturing the TRL of a Complete CDEX Dating Instrument

Table of Contents

Project Introduction	1
Organizational Responsibility	1
Primary U.S. Work Locations and Key Partners	2
Project Management	2
Technology Maturity (TRL)	2
Technology Areas	3
Target Destination	3

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Maturation of Instruments for Solar System Exploration

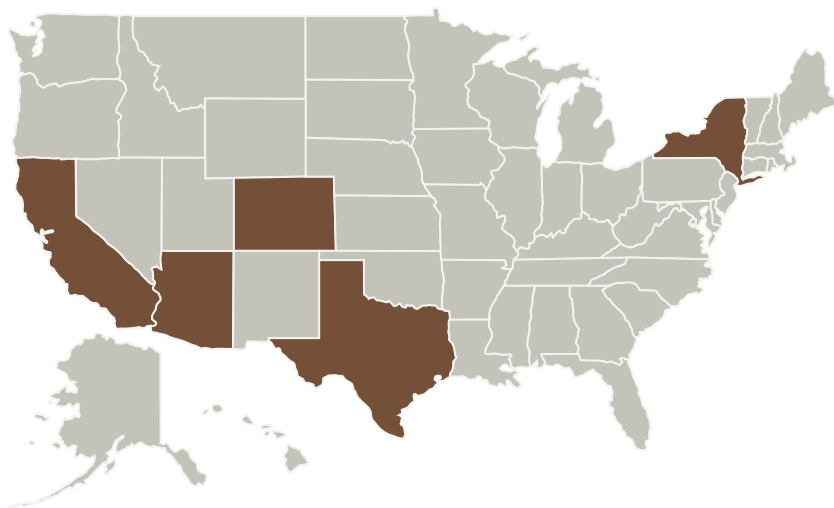
Maturing the TRL of a Complete CDEX Dating Instrument

Completed Technology Project (2017 - 2020)



"development of instruments [including] ... in situ geochronology experiments"; B) MEPAG Goals III.A.3-10, but especially 3, specifically call for "Constrain[ing] the absolute ages of major Martian crustal geologic processes... and the cratering rate. ... with both in situ and returned sample analysis..."; C) For the Moon, the NRC DS has a primary goal of: "Determin[ing] the chronology of basin-forming impacts and constrain[ing] the period of late heavy bombardment in the inner solar system, and thus address[ing] fundamental questions of inner solar system impact processes and chronology".

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Southwest Research Institute - San Antonio (SWRI)	Supporting Organization	Academia	San Antonio, Texas

Primary U.S. Work Locations	
Arizona	California
Colorado	New York
Texas	

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Haris Riris

Principal Investigator:

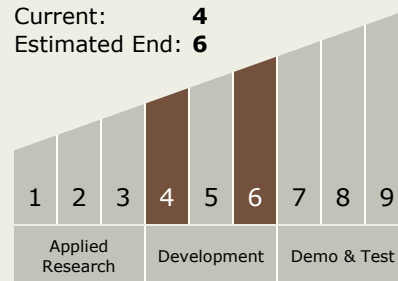
Fletcher S Anderson

Co-Investigators:

Steven M Beck
Jonathan Levine
Arturo Chavez-pirson
Tom J Whitaker
John Andrews
Sean Dougherty
Paul Steinvurzel
Xiaodong Mu
Ronald B Kalmbach
Michael Shoffner
Peter Wurz
Kris Zacny

Technology Maturity (TRL)

Start: 4
Current: 4
Estimated End: 6



Maturing the TRL of a Complete CDEX Dating Instrument

Completed Technology Project (2017 - 2020)



Technology Areas

Primary:

- TX08 Sensors and Instruments
 - └ TX08.1 Remote Sensing Instruments/Sensors
 - └ TX08.1.5 Lasers

Target Destination

Others Inside the Solar System